Chemical Sciences Division

Fiscal Year 2015

Environmental Health and Safety

Self-Assessment Report

Chemical Sciences Electrical Safety

Approved By: A. Belkacem 9/22/15

Ali Belkacem, Chemical Sciences Division Director — Date

Prepared By: Martin Neitzel 9-18-2015

Martin Neitzel, Safety Coordinator, Chemical Sciences Division — Date

Executive Summary

This Electrical Safety Self Assessment evaluated a wide variety of safety related electrical issues throughout the Chemical Sciences Division. Areas of focus were; hazardous electrical procedures or work conducted in lab, faulty equipment or hazardous condition of equipment, outdated building infrastructure, poor or overdue building maintenance, and incomplete aspects of the Electrical Equipment Safety Program (EESP). As a result; we have developed best practices for controlling cables and adaptors with dissimilar ends, repaired all 15 items that required Facilities work orders, addressed all 13 action items identified, surveyed 52 pieces of equipment into the EESP, and took out of service 3 damaged pieces of electrical equipment. As a result of addressing these deficiencies, the Chemical Sciences Division has prevented future electrical accidents and potential fire events.

Introduction

The Chemical Sciences Division conducted inspections and interviews to identify deficiencies in the division's electrical equipment and work practices. Deficiencies were identified in the condition of electrical items, building infrastructure as well as compliance to the EESP. Corrective actions were implemented, and all issues identified were addressed.

Assessment Methodology

Chemical Sciences Division Electrical Walk-Around

Ali Belkacem, Jerry Bucher, Wayne Lukens, Adam Bradford, and Martin Neitzel conducted a walk-through of all CSD Laboratories over the course of three weeks in November 2014. Please see Appendix 1 for the walk-around schedule and contacts.

Areas of focus were;

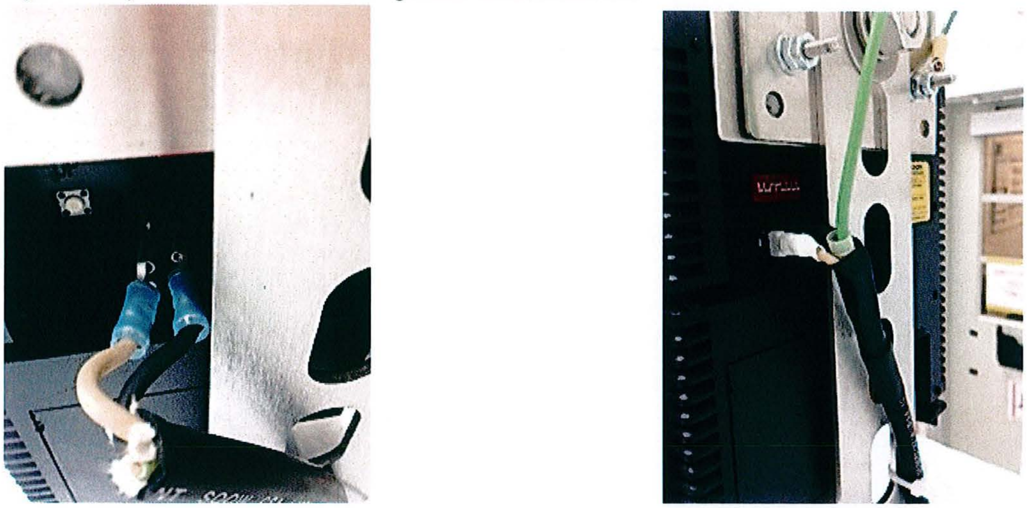
- Electrical procedures or work conducted in lab. (adjustments, calibrating, maintenance)
- Electrical Equipment Safety Program (EESP). (surveys, conditional acceptance, red tags)
- Condition of equipment. (damaged equipment, frayed cords)
- Building infrastructure maintenance or hazards. (elec. panel schedules, knock-outs, panel boundaries)

For each focus area a series of questions were asked to encourage discussion and identify areas for follow up questioning. In addition, the lab spaces were inspected by the team for a wide variety of safety related electrical issues. Please see Appendix 2 for the full description of the LOI and safety related issues that were investigated. Findings were collected as a result of these interviews, and inspections. Many of the issues identified are presented along with a description of the concern. Although a full record of all issues identified is not presented in this report, a summary is presented, and all issues identified were addressed.

Assessment Results

The following findings were collected as a result of interviews, and inspection of Chemical Sciences laboratory areas. Before and after pictures are presented for many of the items that were identified along with a description of the problem area in need of addressing.

Figure 1: Exposed 120VAC on a Refrigerator Chart Recorder.

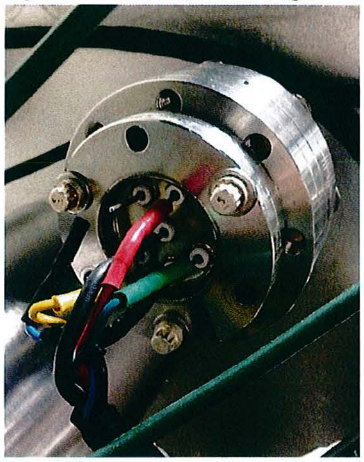


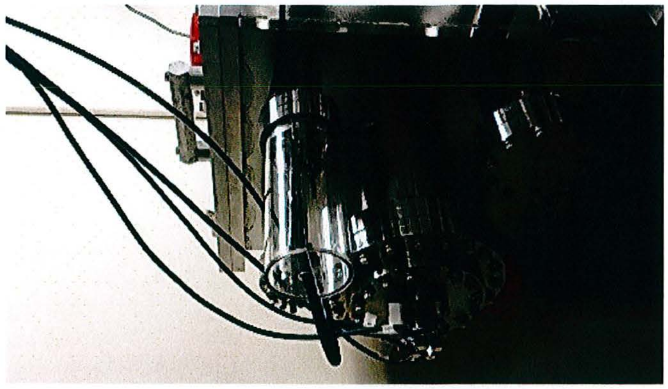
120 VAC wiring for refrigerator chart recorder had exposed electrical conductors and the grounding wire had been cut (figure1). A work request was placed to have the conductor plugs covered and the grounding wire re-attached.

Figure 2: Control Box Opening to Expose Live Wires.

The control box pictured in figure 2 was abandoned in place many years ago and was thought to be de-energized. This item is placed next to the laboratory door in room 70A-1159A. When conditions were just right as the laboratory door shut, the door to the control box would pop open and expose electrical wiring. Testing of the circuit by Facilities electricians revealed that the conductors were still live. Subsequently the circuit was de-energized and the control box was removed.

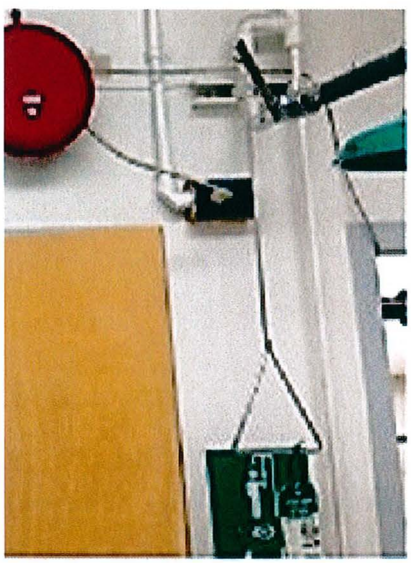
Figure 3: Cover added to High Voltage Pass-through.





The high voltage pass-through shown in figure 3 is used to pass electrical signal into and out of vacuum chambers. The conductors are reasonably well protected by the colored heat shrink, but as an extra layer of safety these conductors were isolated with a cover.

Figure 4: Electrical Plug Removed.



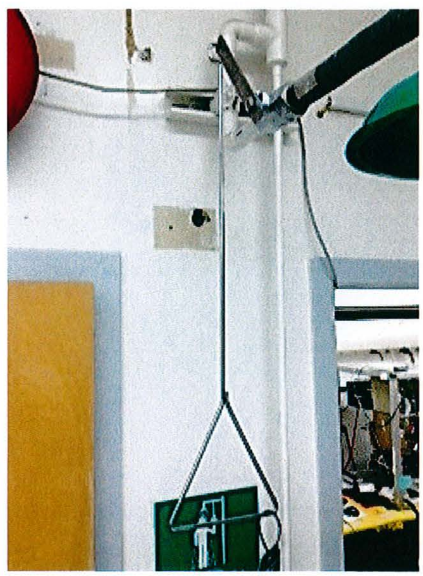
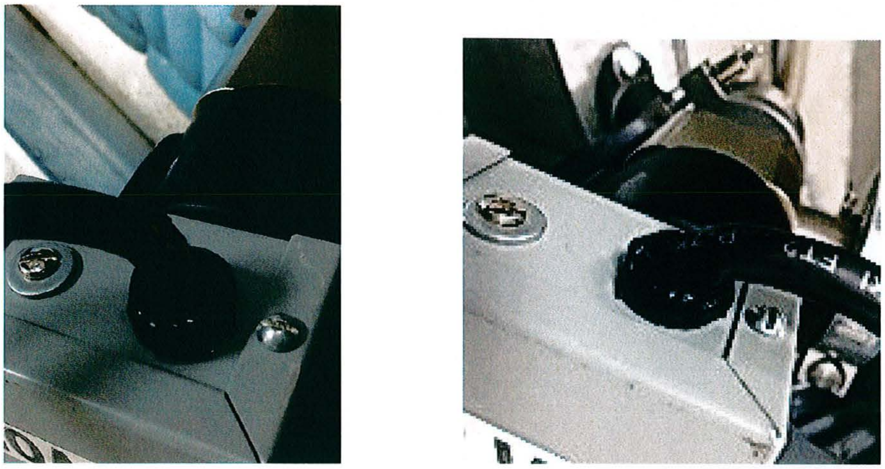


Figure 4 shows an electrical plug on the wall right behind a safety shower. This plug was removed from this location and relocated to a dry location.

Figure 5: Damaged Pump Cord Replaced.



The wire insulation on the vacuum pump shown in Figure 5 was damaged and needing repair. The pump was taken out of service until the cord was repaired.

Figure 6: Hole in Arc Flash Barrier.

Figure 6 shows an electrical panel with a hole in the front cover. This electrical panel has an arc flash hazard as can be seen by the label in the photo, and the cover is a barrier to the arc flash. The hole would have allowed an arc flash to enter into the room, and the workers in this space would have been placed at risk. The hole has now been plugged.

Figure 7: Demarcation tape around electrical panels.

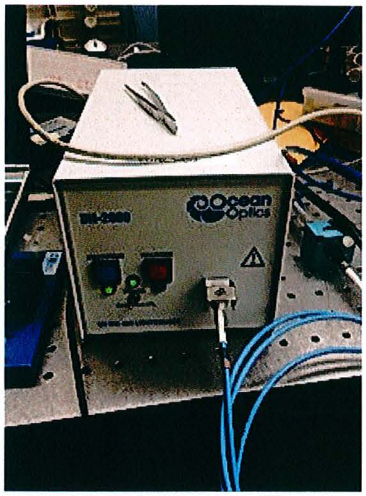
The demarcation tape on the floor in several areas was missing, damaged, or as shown in Figure 7 where the wrong tape was used. All areas identified were addressed.

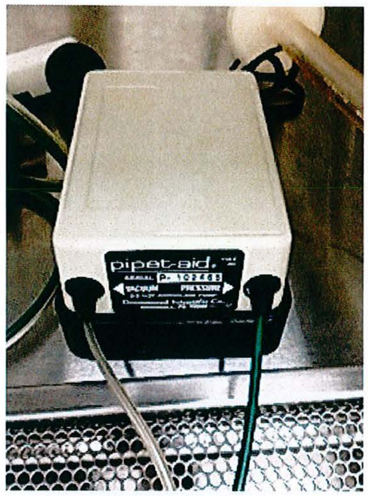
The representative before and after pictures presented here are just a sampling of the items that were identified and repaired. However, in all, 15 items were identified that required Facilities work orders, and all items identified were fixed. In addition, 13 action items were identified such as proper tape on floor, moving items from in front of electrical panels, etc. and all of these action items were addressed.

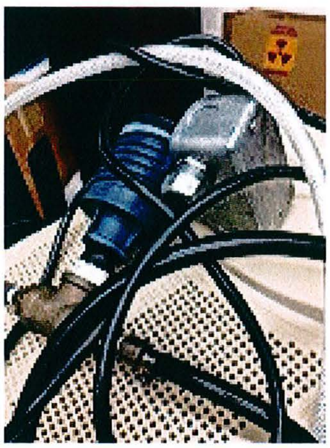
Electrical Equipment Safety Program

All electrical equipment in use at Berkeley Lab must be approved through the Electrical Equipment Safety Program (EESP). Poorly engineered electrical equipment can pose serious electrocution and fire hazards and it is the goal of the EESP to identify this unsafe equipment. Electrical equipment that is not NRTL-Listed must be surveyed into the program, inspected by a qualified electrical inspector, and if needed, repaired by a qualified electrical worker. Figure 8 shows representative item that were identified during this self assessment that were not properly processed in the EESP.

Figure 8: Electrical items deficient in Electrical Equipment Safety Plan.





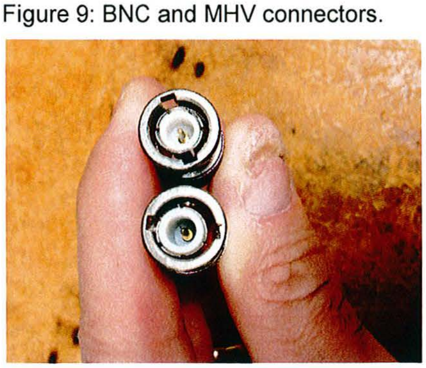


The representative pictures presented here are just a sampling of the items that were identified and addressed. In all, 52 pieces of equipment needed surveyed into the EESP, and all surveys were completed. In addition, 3 items were red tagged and taken out of service.

Electrical cable and adaptor survey

During the course of the electrical walk-around and inspection, Ali Belkacem noticed cables with dissimilar ends. These cables are sometimes needed to connect equipment with one type of connector with another piece of equipment, but when this is done can result in a dangerous situation. A complete survey of all adaptors and cables with dissimilar ends in the division was made (see Appendix 3). Also, procedures for the use and control of these connectors were discussed and new ideas were explored.

Figure 9: BNC and MHV connectors.

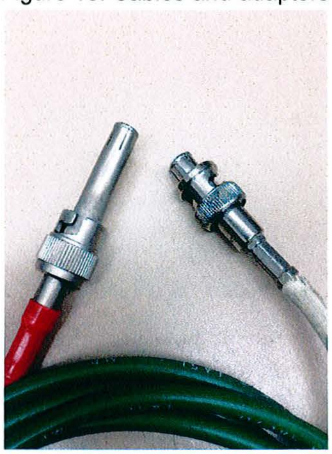


The MHV (miniature high voltage) connector looks almost identical to a typical BNC connector (figure 9), but is not designed to mate with BNC jacks. MHV connectors can be recognized by the slightly protruding insulation on the male plug and the slightly different insulation length in the female jack. Despite these design differences, MHV and BNC plugs and jacks can be made to mate with a little force. This can create a safety hazard, if a user accidentally mates a low voltage cable to a high voltage jack.

Moreover, because of the possibility of high voltage on the exposed central pin when not plugged in and because the ground connection is broken before the power connection when de-mating. It is recommended that researchers use SHV connectors. SHV connectors are designed to prevent these hazards, and cannot be mated to BNC connectors.

Figure 10 gives an example of the type of cables and adaptors that were discovered in chemical sciences spaces, but a complete list can be found in Appendix 3.

Figure 10: Cables and adaptors discovered in chemical sciences spaces.



Chemical sciences personnel have come up with a variety of mechanisms to safeguard themselves and their fellow co-workers from misuse of these cables. Presented here are ideas and suggested best practices for controlling these cables.

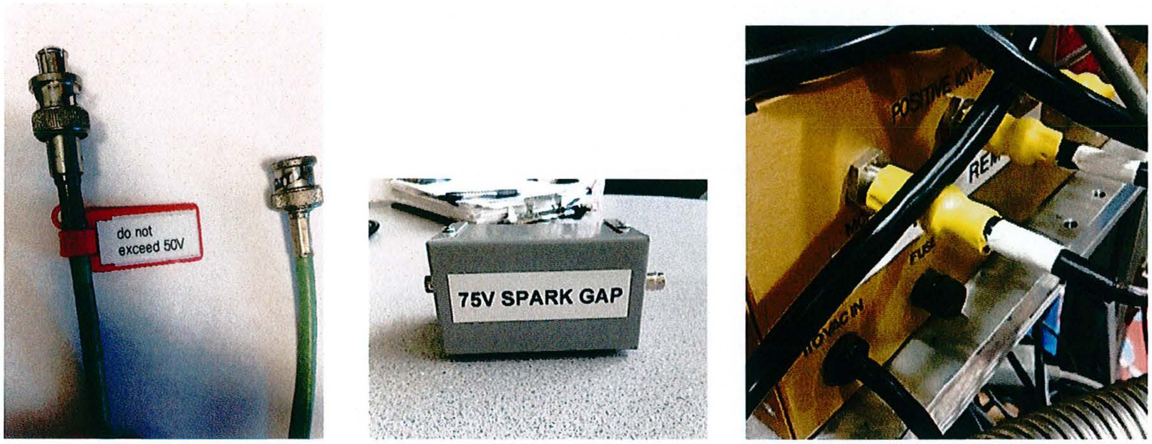
The first suggestion is to keep unusual connectors with a custodian. Several PIs keep the cables and adaptors that they have a safety concern within their office or locked in a tool box. This prevents a novice from grabbing and using one of these connectors without the proper on-the-job training or hazard assessment.

Another way to keep control of these connectors is to heat shrink them permanently onto the instrument (figure 11). This can be done for example with an older instrument containing an MHV output. A MHV to SHV cable or adaptor can be affixed with heat shrink to insure that it stays in place and does not get used improperly or in another location.

Spark-gap boxes can be used to protect from over voltage (figure 11). The MHV connector is typically rated for 5000 volts DC and 3 amperes, but the BNC is not recomended over 500 V. When a MHV to BNC connection is needed, a spark gap box can be designed with the MHV input and the BNC output. The system can then be installed with MHV – MHV and BNC – BNC cables, but the spark gap will protect the BNC cable from overvoltage.

Figure 11 also shows a cable that has been labled in a way to protect it from an over volage hazard.

Figure 11: Examples of safeguards for disparate connectors.



Cables can also be labeled for specific use or with warning information about the cables. In the case pictured in Figure 11, the cable is labeled to prevent an over voltage of the lower rated component.

The final best practice identified for mitigating the hazard associated with this type of connectors and adaptors, is to incorporate training and warning of them into OJT. This is critically important for instance with distinguishing the MHV style connector from a BNC. However, this is also important for all of the best practices identified. These practices will only be utilized if researchers are aware of the danger and of the best way to mitigate the hazard.

Conclusion

Environment, Health, and Safety Self-Assessment is a process of continuously evaluating safety program effectiveness. This Electrical Safety Self Assessment evaluated a wide variety of safety related electrical issues throughout the Chemical Sciences Division.

Areas of focus

- Hazardous electrical procedures or work conducted in lab.
- Faulty equipment or hazardous condition of equipment.
- Outdated building infrastructure, poor or overdue building maintenance.
- Incomplete aspects of the Electrical Equipment Safety Program (EESP).

Summary of Results

- Best practices were developed for controlling cables and adaptors with dissimilar ends.
- 15 items were identified that required Facilities work orders. All items identified were fixed.
- 13 Action items identified (e.g. proper tape on floor, moving items from in front of electrical panels, etc.). All action items were addressed.
- 52 pieces of equipment surveyed into the Electrical Equipment Safety Plan.
- 3 red tagged items taken out of service.

Through addressing deficiencies in the EESP, repairing damaged equipment and faulty building infrastructure, and providing best practices for managing connectors with disparate ends, the Chemical Sciences Division has made great improvement toward preventing future electrical accidents and fire events.

Appendix 1:

Electrical Safety Walk Around, November 2014

Walk-around group

Ali Belkacem <abelkacem@lbl.gov>,
Martin Neitzel <mlneitzel@lbl.gov>
Jerome Bucher <jjbucher@lbl.gov>,
Wayne Lukens <wwlukens@lbl.gov>,
Adam Bradford <abradford@lbl.gov>,

Day 1, please allow ~ 20 min per room.

Building 6-2263; Kevin Wilson <krwilson@lbl.gov>,
Building 6-2261; Musahid Ahmed <mahmed@lbl.gov>,
Building 6-2245; Hendrik Bluhm <hbluhm@lbl.gov>,
Building 6-2211; Bruce Rude <bruce_rude@lbl.gov>

Day 2, please allow ~ 20 min per room.

Building 2-102, 104, 106; Thorsten Weber <tweber@lbl.gov>,
Building 2-333; Travis Wright <twwright@lbl.gov>,
Building 2-321A; James Cryan <JPCryan@lbl.gov>,

Day 3, please allow ~ 20 min per room.

Building 2-355B; Hendrik Bluhm <hbluhm@lbl.gov>,
Building 2-355A, 331; Mary Gilles <mkgilles@lbl.gov>,
Building 2-307A; Stephen Leone <srl@berkeley.edu>,
Daniel Neumark <dneumark@berkeley.edu>,
Annelise Beck <arbeck@lbl.gov>,
Erika Warrick <erwarrick@lbl.gov>,
Building 2-308; Oliver Gessner <ogessner@lbl.gov>,

Day 4, please allow ~ 2 hours.

Building 70A-1159A; Corwin Booth <chbooth@lbl.gov>,
Building 70A-1165, 1159B, 1151, HERL, 2217, 2217B, 2215, 2211, **1152**; Wayne Lukens <wwlukens@lbl.gov>,

Day 5, please allow ~ 2 hours.

Building 70A-2203; Linfeng Rao <lrao@lbl.gov>,
Building 70A-1121A,B,C, 1119, 1109, 1105, 2229A,B, **2223**, 2223A; Rebecca Abergel <rjabergel@lbl.gov>,

If you are unable to attend the walk-through please feel free to invite a knowledgeable substitute. In addition, please feel free to invite anyone whom you feel could add to the conversation.

Appendix 2:

Chemical Sciences Division Electrical Safety Walk Around LOI

Building: ______________________________ Room: ________________________

Please note responses or findings on reverse side.

Electrical procedures:

Do occupants perform any electrical work on or around circuits > 50 V and > 5 mA?

Do occupants work on or around capacitors > 100 V and > 1 J, or > 400 V and > 0.25 J?

Do researchers work on or around batteries > 100 V?

Do researchers have any LBL made or in-house, custom built equipment?

Do researchers adjust, test, calibrate any exposed energized components?

EESP program:

Find any equipment with red "failed electrical inspection" or "equipment out of service" labels.

Find any equipment with yellow "conditional acceptance" stickers.

Find any equipment that does not have either an "AHJ barcode" or green "accepted" sticker.

Condition of Equipment:

Look for damaged, frayed, missing, or otherwise compromised components.

Look for unused openings including conduit knockouts, electrical enclosures, and fittings closed with inappropriate covers, plugs, or plates.

Are cable trays properly grounded, not overfilled, and electrical and water lines separated?

Look for power strips in questionable condition, i.e., frayed cords, damaged, daisy chained.

Extension cords should be appropriate for the load, and not draped over furniture, fire sprinkler lines, crossing walkways, not run through walls ceilings, windows, under mats, across doorways.

Are power and extension cords in good condition, i.e. grounding prongs & jackets in good condition, no frayed insulation, or exposed wiring, no evidence of modification?

Building Infrastructure:

Are GFCI's located on electrical outlets used for heating tapes or mantles?

Are GFCI's located on electrical outlets within 6 feet of water source?

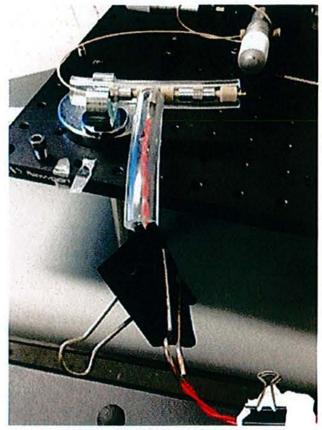
Are all receptacles and outlets in good condition?

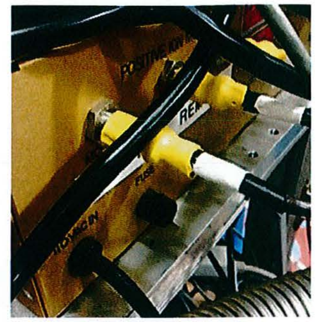
Are all electrical panels and individual breakers labeled and numbered?

Are all electrical panels clear with a 30 in. width and a 36 in. depth and a free access path 28 in. width?

Appendix 3:

CSD Cables with dissimilar connectors survey





6-2261 lab, Musa Ahmed;
- One cable SHV to fully enclosed wire lug.

6-2245, Hendrick Bluhm;
- None.

6-2263 and BL9, Kevin Wilson;
- None in Lab 2263.
- Three at BL with heat shrink in place.

2-104 and ALS BL-6, Dan Slaughter;
- One BNC to SHV5 cable in 2-104.
- One or two BNC to SHV5 cables at BL-6.
- One or two SHV5 to MHV connectors.
- Mostly use spark gap boxes for over voltage protection. Many that convert between SHV to BNC, as well as SHV5 to SHVB.

2-308 lab, and ALS, Oliver Gessner;
- 6 cold cathode gauges with MHV connectors that are connected to their controllers with MHV-to-SHV5 cables.
- 1 multi-contact vacuum feedthrough (company: Roentdek) with 6 fixed cables emerging from the feedthrough that are terminated with SHV5 connectors at their other/loose ends
- 1 SHV5 to BSHV (7.5 kV rating) cable and BSHV vacuum feedthrough
- 1 SHV5 to BNC adapter required to adapt from SHV5 vacuum feedthrough carrying low-voltage fast timing signal to BNC input of fast signal electronics

2-331 and 355A, Mary Gilles;
- None

2-307A; Leone, Neumark;
- None

2-333, 321A, Ali Belkacem;
- 5 MHV to SHV5 Adapters, (2-333)
- One SHV5 to BNC (2-333).
- One SHV5 to SHVB, (321A).
- Two SHV5 to BNC, (321A).
- Two MHV to SHV5 connectors, (321A).

2-102, 106, Thorsten Weber;
- ~20 cables of many different type of connector.

70A, David Shuh;
- 10 MHV to SHV adaptors.